FEBRUARY 21, 1983

CHEMICAL & ENGINEERING

NEWS

Archaeological Chemistry

Page 26

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Cover: Model of a male skeleton with burial goods from about 1500 BC, found in Thailand. Photo courtesy University Museum, Philadelphia

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NEWS
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News of the Week

■ **R&D pioneering areas with the biggest potential picked by panels of experts.** **Page 4**

■ **USDA's Agricultural Research Service aims to rescue American farming.** **Page 5**

■ **Plant-breeding researchers seek a boost from the government with a plea for money.** **Page 5**

■ **Hercules optimistically predicts earnings per share will be up substantially in 1983.** **Page 6**

■ **Foreign genes moved into plant cells retained in plants through several generations.** **Page 6**

■ **ACS Region III councilors choose Heinze, Landis as nominees for director of Region III.** **Page 6**

Business

Rayon is looking to specialty markets to improve its fortunes, also may find growth in East bloc, developing countries. **Page 10**

Polyester bottle resins are one of U.S. chemical industry's bright spots, but demand could exceed capacity by 1985. **Page 13**

Government

Effect of chemical tests on the health of Army volunteers who took part in 20-year testing program charted by NAS. **Page 16**

Advanced technology in industry, employee recruitment cited as impetus for growing university/industry alliances. **Page 18**

Science

Technical Community of Monsanto tears down communication barriers to bridge technical/management gap. **Page 20**

Special DNA regions studied to provide clues as to how genes in complex organisms are controlled. **Page 21**

Solids coated with phospholipid polymer films share properties with the coating, rather than the bulk material. **Page 23**

New theoretical approach predicts thermal desorption rates using only parameters that can be measured experimentally. **Page 24**

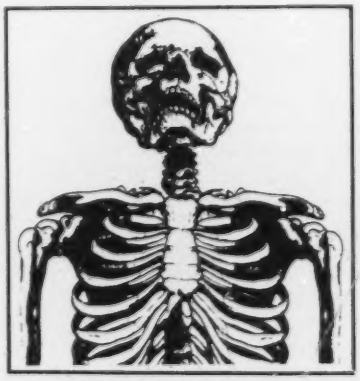
Books

"Safety and Accident Prevention in Chemical Operations" is a good safety reference for any chemical, anytime. **Page 47**

Letters 2
Editor's Page 3

Concentrates
Business 8
Government 14
Science/Technology 19

The Departments
Meetings 52
Newscripts 72



Special Report

Physical sciences play increasingly important role in archaeology, helping in new ways to answer old questions. **Page 26**

Rayon Aims for Specialty Niches in Low-Growth Market

Rayon still will have a struggle in U.S. and Europe, but may find growth in larger markets in East bloc and developing countries

Patricia L. Layman, C&EN London

Earlier this year, a woman in a European clothing shop was admiring a dress that had caught her fancy, and upon protesting a too-high price, was told, "Yes, madam, but it is real rayon."

That is hardly the commonest occurrence these days, of course. But that it happened at all is one indication that the fortunes of the oldest man-made fiber may be changing. From its beginnings as an artificial silk, rayon frequently has been regarded as shoddy, at the worst, or unglamorous, at best. The shoddy image was intensified during World War II, when general shortages of silk and cotton led to its wide use. Some of the applications were ill suited, and the resulting products did not perform well.

Rayon also suffers from being an "old" technology, and over the past several decades, it has seen its markets steadily and speedily slip away to upstart synthetic fibers, petrochemical-based polyester, nylon, acrylic, polypropylene.

From a market that hit its peak in the 1950s and early 1960s, rayon has settled into a holding pattern worldwide. During the past decade, global production fell about 7% to 3.45 million metric tons in 1982, according to the best estimates from companies, the International Rayon & Synthetic Fibres Committee (Paris), and the Textile Economics Bureau (New York City).

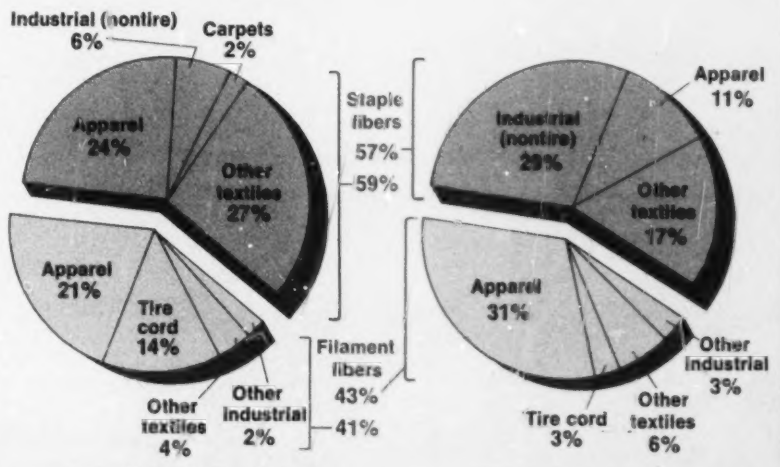
But market erosion may have stopped. Worldwide output in recessionary 1982 was scarcely changed from 1981. For the future, industry sources expect a somewhat split growth pattern regionally. In Europe and the U.S., where rayon has lost ground in recent decades, the outlook is flat at best. However, in the East bloc and developing countries, where rayon has much greater volume, use of the fiber still may grow a few per cent per year. Worldwide, sources expect 1 to 2% annual growth for rayon in coming years.

Growth probably will favor the staple (chopped) type of rayon, which already makes up 70% of worldwide output. This will be especially true if rayon use grows in apparel and other blends with polyester and cotton.

The earliest rayon chemistry goes back to 1883, to the English chemist Sir Joseph Wilson Swan and the French researcher Count Hilaire Bernigaud de Chardonnet. Swan was seeking replacement for silk filaments for the new electric lamp. Chardonnet, however, was interested in producing artificial silk textiles, which he described in his 1883 patent. The chemistry proceeded by way of nitrocellulose, not a particularly pleasant material. And, indeed, rayon historians point out that many of the early experiments, and some early factories, came "to an explosive end." Other researchers, still seeking an artificial silk for electric-lamp filaments, continued the R&D, and in 1891, the cuprammonium process got its start in Germany. Closer to the end of the century, it was adapted to produce an artificial silk fiber for textiles, called glanzstoff.

On paper, the relatively straightforward cuprammonium process has

Staple fibers fill more than half of rayon demand in both Europe and the U.S.



Source: International Rayon & Synthetic Fibres Committee; Textile Economics Bureau

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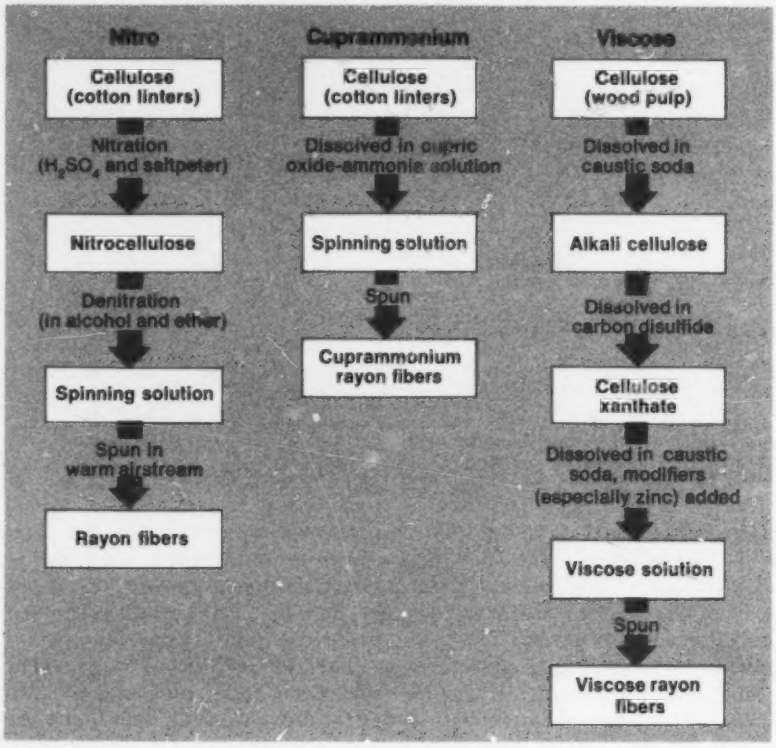
a lot going for it. But copper is expensive and difficult to recycle, which throws off the economics of the process. Only a very little cuprammonium rayon is still made, even though the fibers themselves can produce luxurious, lustrous textiles probably the closest to silk that are obtainable with rayon.

Viscose process for making rayon is a more complex chemistry. But, even though it is "a damned nuisance," as one rayon chemist puts it, because it is so complex, it is versatile enough that a manufacturer "can still play tunes on the chemistry." It got its commercial start with Courtaulds in the U.K., when the company in 1904 bought the British rights (and subsequently the U.S. rights) to the patents of 1892 and 1898 of chemist Charles F. Cross, researcher Charles H. Stearn, and glassblower Charles F. Topham, all of the U.K. Cross's master patent of 1892 covered the viscose process; the Stearn patent of 1898 covered the production of filaments from viscose; Topham's various patents described mechanical devices for processing and spinning the viscose rayon fibers into yarn.

Rayon makers have had to work out a few problems along the way. Primary among them have been environmental considerations, to handle the problems associated with the viscose process. Cleanup costs have been considerable. Enka, Akzo's fibers unit, for example, estimates that the cost of installing cleanup equipment at its Arnhem, Netherlands, plant was $10 million, with subsequent annual costs of $2 million. Similarly, Avtex spent $12 million on an air-emissions control unit at its Front Royal, Va., plant, besides working out a water treatment system that, it now boasts, sends out water cleaner than it comes into the plant. Producers have those costs under their belt now, so they don't have much present impact on the manufacturing costs of rayon, or subsequent selling prices.

Those prices are competitive with prices for polyester, marketers now insist. That is a far cry from the early 1970s, however, when oil was $2.50 a barrel, and seemed as if it would remain there forever. That meant that both the polyester raw materials and its energy processing costs were low. And abundant overcapacity ensured that the price was low. Compound that with the hefty environmental control outlays facing rayon makers at that time, and the overcapacity for the fiber, and it's no wonder a few companies wanted out.

Hazards of nitro process led to adoption of cuprammonium process, but viscose versatility finally proved most popular



FMC Corp., for one, wanted to sell off its American Viscose operations. It probably was ready to close the operation down completely had not the unit's management put together an employee buy-out, forming Avtex. As another example, American Cyanamid closed down its rayon production.

And even those companies that stayed in the business have had to take a long—and realistic—look at the future of the fiber, to decide how much research and development support to give it. Avtex and Courtaulds are concentrating R&D on their now modified rayon fibers, and are into market development for still relatively untapped industrial-fibers markets.

Enka earlier was spending significant amounts of R&D time and money on a new solvent-extraction process, to get away from the complex viscose chemistry. But the most promising solvent was an amine oxide, and that put the work on the back burner. Amine oxides feature a typical fragment amine aroma, so they must be completely recovered—just as manufacturers now have to do with carbon disulfide and its breakdown products. But more important, the amine oxide wasn't available commercially. Had Enka adopted a process based on it, the company would have had to build an amine oxide plant, or arranged with another company to build one for merchant supply. It all would have cost even more than a new viscose plant, Enka concluded—for a process that could not really obtain the performance versatility of the viscose process.

It hasn't helped such development decisions that some of rayon's old stalwart markets have been hurt. Here, however, there are regional differences. From its predominance

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Production of cellulosic fibers has risen in East bloc and Asia over past decade

Thousands of metric tons	U.S.	Non-U.S. Americas[a]	Western Europe	East bloc[b]	Asia[c]
1971	718	166	1092	879	712
1972	728	172	1085	960	756
1973	731	179	1121	1011	790
1974	668	166	1045	1064	779
1975	470	142	769	1083	698
1976	518	141	884	1115	770
1977	547	145	950	1062	813
1978	560	142	948	1065	851
1979	588	152	963	1047	880
1980	551	147	871	1068	877
1981	539	135	826	1036	927
1982[d]	525	130	810	1050	930

a Argentina, Brazil, Canada, Chile, Colombia, Cuba, Mexico, Peru, Uruguay, and Venezuela. b Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, U.S.S.R., and Yugoslavia. c Bangladesh, China, India, Iraq, Japan, Pakistan, South Korea, Taiwan, and Thailand. d Estimates. Note: Includes acetate textile fibers (about 5 to 7% of total, but excludes acetate tow for cigarette fibers. Sources: International Rayon & Synthetic Fibres Committee (Paris); Textile Economics Bureau.

as a tire cord in the U.S. in the 1950s, for example (C&EN, July 26, 1982, page 13), rayon now has only about 2 to 3% of the U.S. tire-cord business, a percentage identical to that held in Japan. In the developing countries, rayon holds 25% of the tire-cord market. But in Western Europe, it is the largest man-made tire fiber, holding a fat 21% of the tire-cord market. It is second only to steel, which—because of its heavier weight—holds a 69% share, thanks to radial tires having 95% of the passenger-car tire market. In fact, rayon is the carcass reinforcement cord for up to 80% of passenger-car tires in Europe.

The developing nations have been the scene of some dramatic rayon expansion. Among the reasons are the requirement in warm countries for comfortable fibers, with comfort being one of rayon's best characteristics, and the natural-resource base that many countries possess.

A domestic source of raw materials, too—cellulose from wood pulp—is not necessarily all it takes. The Enka tire-cord plants in Europe, for example, get their wood pulp from U.S. southern pine forests, rather than Scandinavia's northwoods timber; so do the rayon tire-cord plants in India. Courtaulds' textile-fibers plant in Cornwall, Ont., Canada, and in Mobile, Ala., get their wood pulp from Courtaulds' subsidiary in South Africa. Moreover, conservationists are concerned that developing countries' forests are being stripped, altering the ecology of an area, with no reforestation programs under way.

The natural-resource aspect of rayon eventually must become more attractive. However, eventually may take some time. Many rayon marketers are prepared for petrochemical-based synthetics to make inroads on rayon even in developing countries, although perhaps not to the same extent that synthetics have in Western Europe, Japan, and the U.S. They also expect such developing countries to continue to concentrate on apparel and textile production, which can provide employment with low labor costs, particularly with government subsidization. And even though recent capacity buildup has been in the East bloc and in the developing countries of Asia, some Western rayon producers believe that there are indications that those countries are beginning to take steps to adjust capacity to reflect consumption.

For now, worldwide rayon capacity is adequate, but not ample. In Western Europe, for example, filament-yarn production has been running at about 90% since a shutdown in 1980 of roughly 10,000 metric-tons-per-year capacity. In the U.S., the utilization rate is somewhat lower, probably slightly less than 80%. As rayon producers point out, that's still quite a bit better than most other man-made fibers these days. But they argue that, given the generally stable consumption outlook for rayon, there is little economic justification for more rayon plants in the future.

Other European producers, for example, are nettled by the recent announcement by rayon producer Snia Fibre, in Italy, that it will build new rayon facilities with an initial capacity of 6000 metric tons per year of rayon filament. Nearly all of the investment will come from the Italian government, and other rayon producers see that as subvening the existing European agreements on fiber production.

Producers of rayon filament are particularly upset because the proposed Snia addition would be bound for the largest rayon-filament market—in linings. Linings presently make up more than half of Western Europe's rayon-filament textile consumption of about 40,000 metric tons per year.

In one effort to lessen dependence on such specific markets as linings, Western rayon producers are adopting "engineering" as their password, as they seek specific market niches for their fibers. They clearly have lost the battle for commodity fiber markets throughout the world, so their marketing approaches now reflect that fact. Specific demands—from the mundane world of nonwoven diaper covers to carbonized rayon used as an ablative covering for space shuttles, hollow fibers to give extra warmth and fullness for blending into thermal fabrics, extra-absorbent fibers for medical and hygienic products—all these are part of the new effort.

In the U.S., the Rayon Council holds seminars and programs to kindle the interest of young chemistry and textile engineering students in what has long been considered a humdrum, old-auntie fiber. And producers try to steer their customers into using the fibers in suitable applications, away from unsuitable end-uses. Those unsuitable applications led in the 1930s and 1940s to the image that rayon is finally starting to live down, as specially selected end-uses boost it in its uphill battle to be respected as "real rayon." □

Industry support of academic research growing

The widespread belief that a significant deterioration occurred in university/industry relationships during the 1960s and 1970s is more myth than reality, according to the National Science Board's fourteenth annual report to Congress. "There are many indications that such relationships remained both vigorous and varied," the report says.

Further, corporate support of academic research is significantly higher than generally believed, according to the report. It is true that during the early 1960s industrial support stayed flat at about the same constant-dollar level. But since 1965, constant-dollar support for university R&D from industries has doubled.

The report also takes issue with the oft-cited base figure of between 3% and 4% for industry support of total academic R&D. For a more complete picture, it says a number of omissions need to be added to the database. Among these omissions, the report says, are major research universities that do not report R&D expenditures from industrial sources. Industrial gifts and loans of scientific equipment are rarely included in the database. Also, many universities do not count as industrial support gifts for research from corporate-sponsored foundations. And many universities do not estimate the portion of unrestricted corporate gifts for operating and capital funds that eventually are spent on research facilities, equipment, and faculty and student fellowships.

If all of these omissions are taken into account, the report says, it is not unreasonable to estimate that the current corporate contribution to total academic R&D is in the neighborhood of 6 to 7%. This represented a sum between $400 million and $450 million in 1980–81. As support for this estimate, the report points to a 1981 survey of all departments listed in the American Chemical Society's Directory of Graduate Research, which showed that 7% of extramural research support for chemistry departments and 23% for chemical engineering departments came from industry.

If these current levels of corporate contracting and philanthropy for academic research are maintained through the current business recession, more reinforcement will be provided for already "sound reasons to believe that we may be at the threshold of a permanent new state of corporate-academic research relationships," the report states.

One of the major reasons for believing that the number of university/industry relationships can only increase is that problems and opportunities in today's technologically based industrial production are substantially different from those of the past. For example, the report points out that product and process improvement and innovation in some industries have evolved to levels of complexity that demand understanding of fundamental physical and biological phenomena. Hence, these corporate activities require much higher levels of training in and use of basic science and engineering than the "cut and try" inventor of yore had. In addition, incremental advances in narrowly focused technical areas, characteristic of much industrial development in the past, are giving way to the use of a broad range of science and engineering disciplines on complex, often ill-defined problems, or exploitation of new analytical capabilities. Hence, it is becoming increasingly difficult for one industrial laboratory to encompass the requisite expertise.

Therefore, industry will be looking to universities for solutions to very specific scientific problems in which the university has special expertise. This in turn will lead to broader relationships. A field study done for the report found that the initial impulse in the majority of university/industry relationships sampled came from the university, with a significant portion of the academic researchers pursuing these relationships having had prior consulting or other employment relationships with companies. Thus, the report says, "We have a multistage series of relationships: Company wants technical/scientific advice (general or specific) and seeks out a professor; professor/consultant sees opportunities for research and initiates research relationship; company tracks and (maybe) utilizes the research and makes employment offers to the bright graduate students and postdoctorals working on the project; and the cycle is repeated in future years."

However, the report cautions that the focus on research interactions should not obscure the primary interest of research managers in making research connections with universities: manpower acquisition. Recruitment at the leading edge of science and engineering is a highly competitive process; thus it is reasonable to suppose, the report says, that some significant portion of the current upswing in industrial support of academic research is directly related to manpower concerns. □

Most industry support for university research departments goes for specific projects

Type of support	Chemistry $ Thousands	Chemistry %	Chemical engineering $ Thousands	Chemical engineering %
Grants or contracts for specific research projects in response to explicit proposals	$ 5,516	54%	$ 4,477	44%
Gifts or grants to specific faculty members or for specific research areas	2,469	24	1,845	18
Uncommitted gifts or grants to university departments	1,910	19	3,139	31
Membership fees from industrial associate programs	260	3	564	6
Other	59	<1	157	1
TOTAL INDUSTRIAL SUPPORT	$ 10,214		$10,182	
Total extramural support	$145,672		$44,338	
Industrial funds as % of extramural funds	7%		23%	

Note: 72% or 136 of the chemical departments surveyed responded, as did 81% or 79 of the chemical engineering departments.